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BIM and Architectural Heritage

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Abstract

Heritage buildings are crucial in the human perception of culture and identity over time. The sustainable retrofit of these buildings is an opportunity to reuse them taking into account sustainability. HBIM tools (historical building information models) can be used as a comprehensive data collection of information, particularly in the area of building restoration. Based on an international interesting on this kind of studies, the reconstruction process is carried out using BIM software, which shows attention on the software methodology and model structure, and at the same time clarify the added value of a BIM approach, when compared with more traditional CAD modeling systematics. Of particular interest is the approach integrating with more traditional 2D documents and for visualizing reconstruction assumptions within the 3D model representation. BIM focuses mainly on a structured approach to the overall analysis of the architectural object and the organized archival of the reconstruction project. Though virtual reconstruction is not an innovation, this paper explains the methods of preservation of architectural heritage, and the stages of BIM implementation in the digital reconstruction and restoration this kind of buildings and the most important techniques used. Also, explain the application of BIM for modeling and information presentation in different formats. The house of Hamed Saeed in Egypt built by Engineer Hassan Fathi in 1941, is an example. Beside of other examples from different countries worldwide and have just studied by this techniqueClick here and insert your abstract text.

Keywords: BIM; modeling; reconstruction; restoration; software

1. Introduction

This paper discusses how the technology of building information modeling can be used to preserve Architectural Heritage (AH**).**

Heritage Building Information Modelling (HBIM) is a term that has only begun to be used in the latter part of the last decade. Since Building Information Modelling (BIM) superseded 3D digital modeling and computer-aided design (CAD) as the term which describes the use of information and communication technology (ICT) for the construction, design, and procurement of the modern built environment.

It is sometimes also defined as historical Building Information Modelling, a somewhat narrower term (Murphy et al. 2009).

Building information modeling for historical buildings: is the digital representation of the physical and functional characteristics of historic buildings based on the contemporary state of the historic building. Taking into account all the stages passed by the building including additions, modifications, and restoration work. It is mean some intangible things, such as association, identity, memory and cultural value. “increasing resource scarcities require improved analytical tools for conserving existing buildings in general, and mitigating climate change; and that Heritage buildings

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form a particular challenge, due to the need to conserve their historical and aesthetic worth, addressing environmental social and economic sustainability."[1].

These pillars of sustainability are not fixed; perceptions of quality of life change over time with resulting dissatisfaction with heritage structures and a view that they have become unfit for their purpose [1]. As said the authors of [1] in preparing for the workshop on HBIM in March 2015 in Luxor, Egypt, also claimed that the "Heritage Buildings that are most relevant and at risk were not so much unoccupied national or internationally important monuments, but the cultural backdrop of occupied architecture that: has historic and aesthetic value; demands particular maintenance and refurbishment skills and analysis; deploys expensive materials that may be in increasing shortage; and generally cannot affordably be replaced with better performing new constructions [2].

1.1. Methods of Preservation of Architectural Heritage

Whatever the reason for maintaining the site, conservation should be provided not only to individual units but to the original features of the region as a whole.

Conservation methods vary depending on the type and condition of the impactor architectural heritage and include the following methods:

- REbuild/REproduce

This method involves the reconstruction of old buildings as it was in the past.

- REstore

Restoration of historic buildings and pieces, as in the past.

- REnovate/REinstate

The renewal includes the use of modern materials and attempts to transfer the impact to a condition close to its condition at the time of its construction.

- REvitalization

The process of revitalizing the heritage area as a whole to what it was before, by adding activities and facilities that existed before.

- REctify

To promote the urban, social and economic area in order to improve the level through the addition of activities that were not present before, and consistent with the requirements of the modern era.

- REuse

Includes the use of the building in the same purpose for which it was created or used in a new manner.

1.2. Conservation of the architectural heritage:

It is gradually linked to the periodic maintenance of monuments, thus making preventive maintenance as a real necessity in daily practice. The three-dimensional geometric and structural models have scientific and practical value. They provide support for advanced preventive maintenance programs for architectural heritage and help to maintain over time.

On the other hand, virtual models have great potential for sharing and disseminating knowledge over the Internet and documenting the historic building in all material and non-material contexts. In addition to understanding the historic building and its architectural elements, conducting analyzes and studies about the foundations and infrastructure, and any problems expected in the future and identifying the damaged sites in the historical building and follow-up during his life cycle.

More importantly, give a comprehensive overview for decision-makers with the participation of this model with them, which helps to make the right decision towards these buildings.

It is also possible to take advantage of the historical buildings information modeling in the creation of a specialized architectural library that includes all the details and architectural elements of historic buildings, and also can be used in modern projects, which helps to preserve the authenticity of these elements and their golden proportions.

1.3. Management and maintenance of cultural heritage buildings

The tasks related to the management and maintenance of cultural heritage buildings urgently need comprehensive information on the complete characteristics of the building to carry out. To facilitate this; a large amount of data should

be collected from various sources and in various file formats. Then an integrated information system can be created that covers all the physical and functional characteristics of the building. Indeed, the required data can be very heterogeneous. That mean the documents, plans, historical maps and graphical texts, as well as the latest data from historical structural investigations and geodetic surveys?? Geodetic surveys or photographic survey. Given that all architectural heritage objects are inherently 3D spatial properties, the resulting information system, which will include all of the above documents, should allow the management of 3D models. Even this may not be enough because we often need to represent a 4D historical building to describe its changes throughout time.

The disciplines that intersect with the use of building information modeling in many historic buildings include architecture, civil engineering, materials chemistry, sustainability, history, and heritage, as well as the specialization of geomatics and Photogrammetry. These disciplines contribute directly and indirectly to enriching the modeling of historical building information modeling in many aspects, including the identification of used materials and the old methods of building and methods of restoration and maintenance of these buildings.

The current development of new and more effective digital technologies, such as building information modeling, 3D modeling, laser scanning techniques, animation, and simulation, has opened new scenarios for reading and interpreting architectural heritage and facilitating the movement of its designs. This is particularly useful in maintenance and restoration.

Now it is possible to build models of existing buildings, demolished buildings or buildings that were not originally built, not only as the original or as built, or some intermediate stages, but also by taking into consideration the design intentions, the building constraints, and variables. By adding the fourth dimension of the historical building model. Depending on the modeling of construction information, architectural details or structural elements often show periods of construction of the historic building and any increases or modifications to the building. For example, there are temples and ancient houses that were not built at once, but in different stages and periods of time. For example, the house of Hamed Saeed in Marj and built by Engineer Hassan Fathi, the house was built in two phases in 1941, the main interior unit was built, consisting of a central chamber covered by a dome and connected to a vaulted Iwan. It refers to the hall, i.e., the typical main room of the historic houses of Cairo, and there is an exterior, large arched Iwan (Arcade) was built near the room and overlooks the rural nature. In the second phase of 1945, he designed additional rooms around the tree-lined courtyard: the number of two main rooms on each side, and two double rooms (each unit consisted of a room covered with a dome connected to a smaller unit), all connected to a covered arcade on the other side. And the rooms are covered with a dome, except for the two (Iwans) and the Riwaq (Arcade) covered with the arches.

For historical buildings such as the Luxor Temple and other historical buildings, the use of building modeling is not difficult, but the difficulty lies in knowing what is behind the walls. For example, in many historical buildings, specialists study parts of the walls to know the structure and physical properties of the walls. Many times, some structural elements are invisible, which may lead to the use of the wrong method or structural element by the specialist. In this case, you should use more advanced means such as XRF and others, to build a valid model and get the required analyzes and studies correctly.

1.4. Stages of Application of Building Information Modelling in Historical Buildings:

Building information modeling in historical buildings is applied in three phases:

- The first stage is the collection of data from the site and always uses laser scanning technology and photogrammetry to collect the most detail, accuracy and in high quality.
- The second stage is the phase of data processing.
- The third stage is the building of the model divided into categories such as floors, walls, and doors.

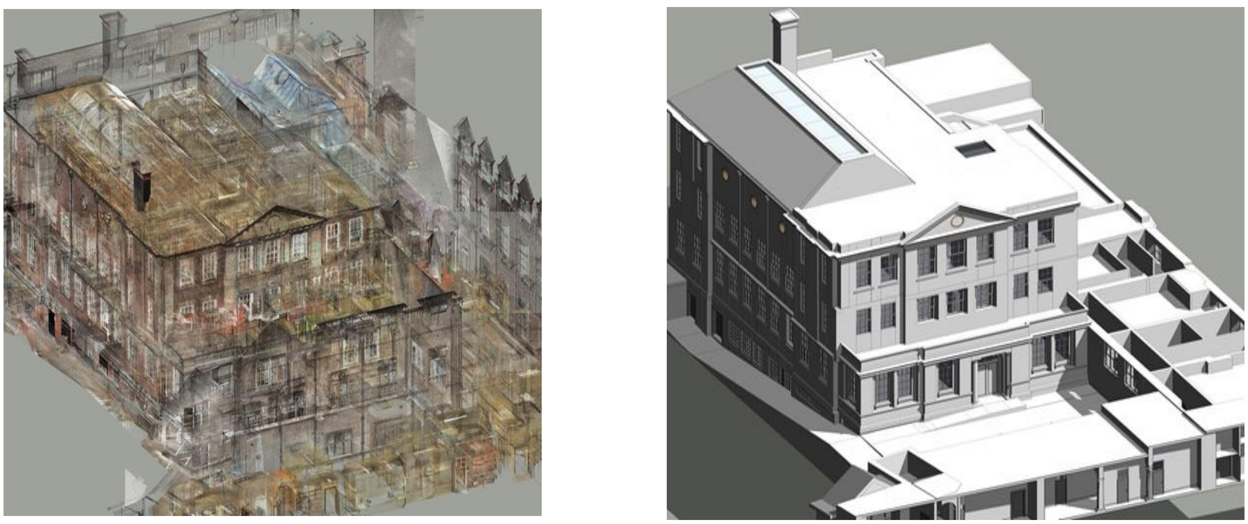
Based on the available information from the laser scanner and the architectural survey, the model is divided into "work sets" with building elements such as walls, doors, floors, stairs, and pipes. All other team members can view these items but they are not able to change them, and any information available on the site is added as construction site and architectural plans, reports, and works of restoration and maintenance, method of construction, historical documents, the differentiation of structures according to the stages of construction and other information.

The definition of a 3D laser scanner is a tool that analyzes structural elements or an urban environment for the collection of spatial and physical information related to its shape and appearance, followed by the process of using the collected information for the purpose of constructing a three-dimensional digital model as a copy of the original used

in a wide range of applications. The formation of a cloud of points for the geometrical coordinates of the elements of the surfaces of the documented form through the pulse or continuous projection of a laser ray is the main and typical stage in this technique, through which digital models are formed for the original element. The colors of the finishing materials of the documented elements can be scanned and digitally created when using the feature of (Clear Color Info) for each point during the scanning process.

Photogrammetry is a science and technology specialized in acquiring information about elements and the physical environment through the process of recording, measuring and interpreting photographs. It is one of the formulas that rely on the use of a camera which can be adjusted or metric camera instead of other scanning tools. This camera has a lens that can be changed and controlled. This means that the lens is accurately measured and that the focal length of the camera is known. It also has a special plate attached to the film to save its negative surface when taking pictures. This plate projects small intersections in the form of (+) on the output, any distortion that appears on the image will be determined at the exit process.

Photogrammetry is a standard technique that identifies the three coordinates (x, y, and z) of the component points of the element through measurements that can be obtained from two or more photographs of the building or scene taken from different locations. Commonly used to interpret the elements: what is it? What sort? What is its quality and/or quantity? Also used to measure elements: Where are they? What is its structure or size?



D Scanned Image of Educational Centre, London, UK BIM Model of Educational Centre, London. [3]

Fig.1. (Creating intelligent 3D BIM workflows and information-rich models from laser surveyed data images and the point could capture by drones.)

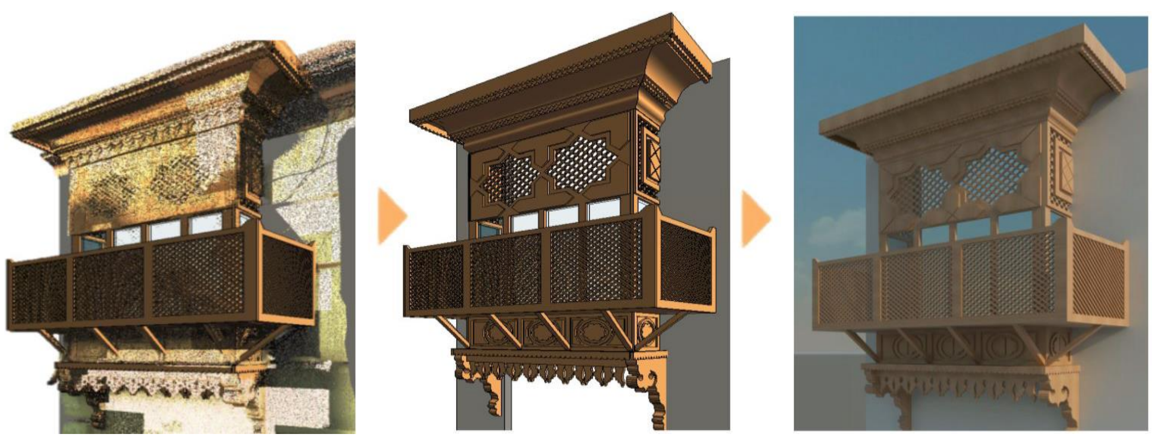


Fig.2. Creation and visualization of a 3D model based on a point cloud. Source (Jeddah Historical Building Information Modelling "JHBIM" – Object Library)

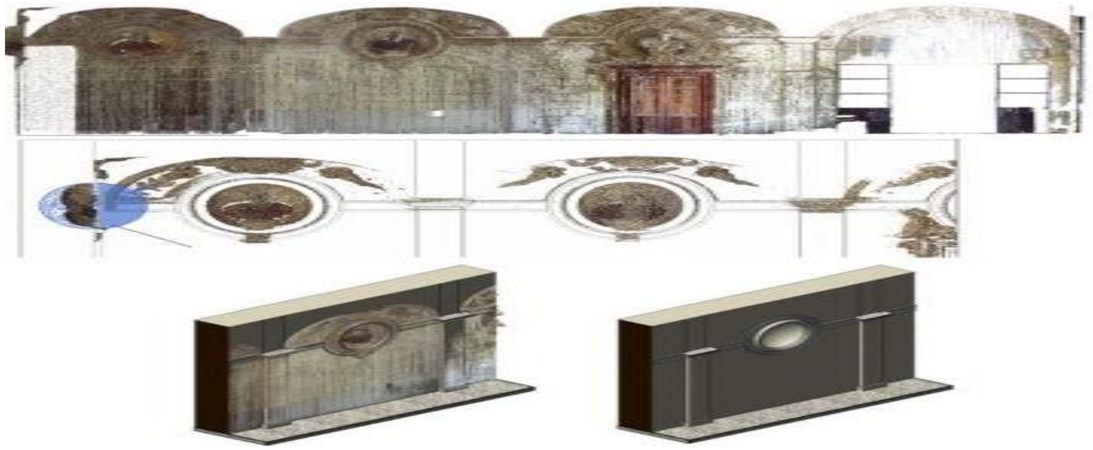


Fig. 3. Valentino Castle. The architectural elements were divided into groups with different levels of shape recognition difficulties and were treated accordingly. Source: BIM Methodology as an Integrated Approach to Heritage Conservation Management.

The techniques used to transform the building into a three-dimensional model are many, but even today there is no technique to transform the historic building or buildings directly into a complete model in a fully automatic manner. The advanced techniques used in many historical sites in Europe are laser surveying and architectural surveying. They are then modeled using the automatic method of predefined parts such as drainage, air conditioning, and electricity; while the more complex parts are often modeled according to specialists.

The degree of detail varies according to the objective of using the building information model for historic buildings. Here, one must distinguish between the use of building information modeling and the use of advanced scanning methods such as laser scanning. For the laser scanner, the output is the outer shell of the walls and the elements to be scanned. For example, if we want to make a laser survey of a historical building in the outputs, the outer shell of the building will be inside and outside. In this case, we can produce a three-dimensional model, horizontal projections, and facades, and this information may be used in the presentation, virtual reality, quantities, specifications of materials and others. The role of building information modeling for historic buildings is to transform the laser survey outputs into a complete model that contains the quantities and specifications of the physical building, the properties of the materials used and other known uses of building information modeling. See figures 2, 3.

1.5. Obstacles to the use of building modeling for historic building:

It can be divided into the following:

- Difficulties in historical sites, which are complicated in several aspects: geographical complexities in the site or geometric complexity in the form of the building in terms of design, etc., complexities in obtaining permission from the responsible authority or the owner of the site, in addition to the danger of some sites and historic buildings, especially those threatened by failures.
- Technical difficulties in the absence of an architectural library of such historical buildings and architectural elements, while the architectural library of modern buildings is very rich in architectural details or as called (blocks). For example, if you look at any building information modeling software for a particular door or window, you may find many shapes and designs that you may find from the manufacturer and all you need to add or include in the model. On the other side, a historical architectural element such as Mashrabiya (Rushan) is very difficult to find but must be rebuilt from the beginning to fit the historic building. This is in addition to the lack of most of the architectural materials used in such buildings, for example, the special stone, and the provision of “blocks” for temporary equipment of construction used during the construction of the archaeological building.
- Physical problems and obstacles arise in the high costs of using technologies such as laser scanner, in addition to the high costs of modeling historical buildings and the lack of specialists in this field at the national and international levels.

- The volume and quantity of data produced from it that may pose challenges and difficulties in processing and transfer. To solve this problem; there are several simplest ways to set up the site and make a good laser scanning plan so that the desired target is selected and the clear angle is chosen so that the minimum number of points of laser scanning is done, taking into consideration the accuracy required for the laser scanner.

One of the advantages of using building modeling in historic buildings is to dispense of Point Cloud files after completing the modeling in a manner that may lead to total dispensing and rely on the building information model in analyzes, studies, presentation, etc.

1.6. The most prominent Arab/ international organizations that used building information modeling in historical buildings

After the support of British government to the idea of using building information modeling for modern projects that cost more than 5 million £, attention has been drawn to the potential benefits of using this technology in existing buildings, projects and historic buildings. One of the organizations supporting this trend is English heritage. Unfortunately, there are few of prominent projects that benefited from information modeling technology for historic buildings, including , as mentioned above, the Sagrada Familia Cathedral in Spain, the castle of Mascara in Italy, Lerico in Milan, the study of the towers of Milan Cathedral, and the historic building of the Naseef House in Jeddah.



Fig.4. On the left side is a house of Nassif, a product with a laser scanner, and on the right side is a building information model for the historic house of Nassif in Jeddah, Saudi Arabia JHBIM. [4]

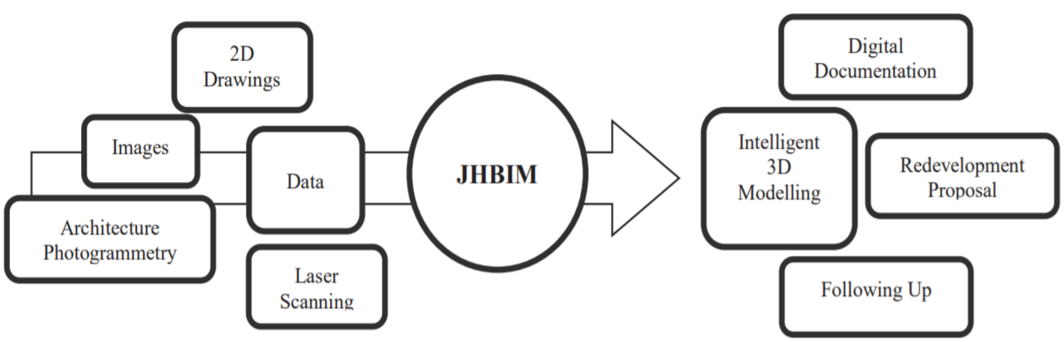


Fig.5. JHBIM Approach from Baik et al [4]

An initiative called Jeddah Historical Building Information Modeling (JHBIM) deals with the archaeological buildings in Jeddah and aims to introduce BIM tools to document the historical buildings in Jeddah. Traditional survey methods are being used to create data on existing buildings. These tools have high costs, often consume a lot of time and will help the importance of such a database in determining their circumstances and making decisions regarding the management, reuse, and maintenance of these buildings.

You can take advantage of the experience of countries such as Italy, the UK, Canada and Spain. One of the most famous historical projects in which building information modeling was used was the Sagrada Familia Cathedral by architect Anthony Gaudi, whose work began in 1882 until now. The technique of building information modeling has helped to build many complex elements of the building that are difficult to construct at the time [5].





Sagrada Familia   Model Manchester Town Hall Complex. Source: (Manchester Central Library)

Fig. 6. The most important historical projects for which building information modeling was used

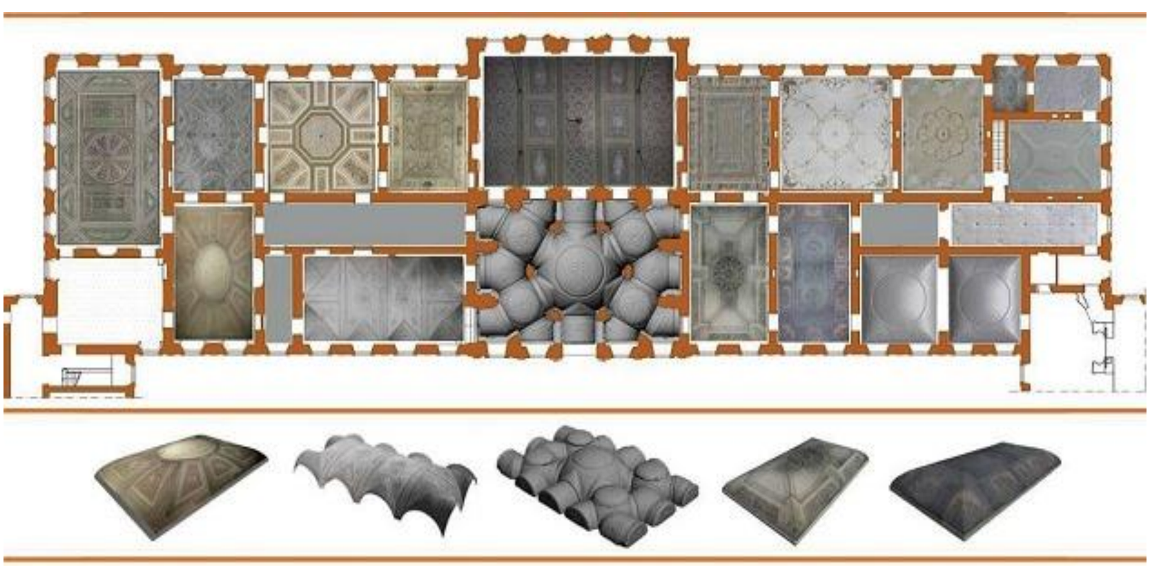


Fig.7. Results of multiple surveys of the Villa Reali di Monza building in Italy using laser scanner as part of the policy of preservation and management of building information. *Source: (Historic Building Information Modeling - HBIM) Dr. Emad Hani Al-Alaf*

1.7. The most important PIM programs used in the work of architectural heritage model can be divided into:

1- Software convert cloud points from the laser scanner to model elements such as Autodesk ReCap

2- Programs for model creating such as Edificius Free UPP & Revit & ArchiCAD & TeklaStructures
3- Software for cities such as Autodesk InfraWorks 360
4- View of the model such as Tekla BIMSight & xBIMXplorer
5- Analysis such as Green Building Studio
6- Software for adding a fourth dimension such as NavisWorks
7- Facility and facility management software such as ArchiBUS or GraphisoftArchiFM. [6].

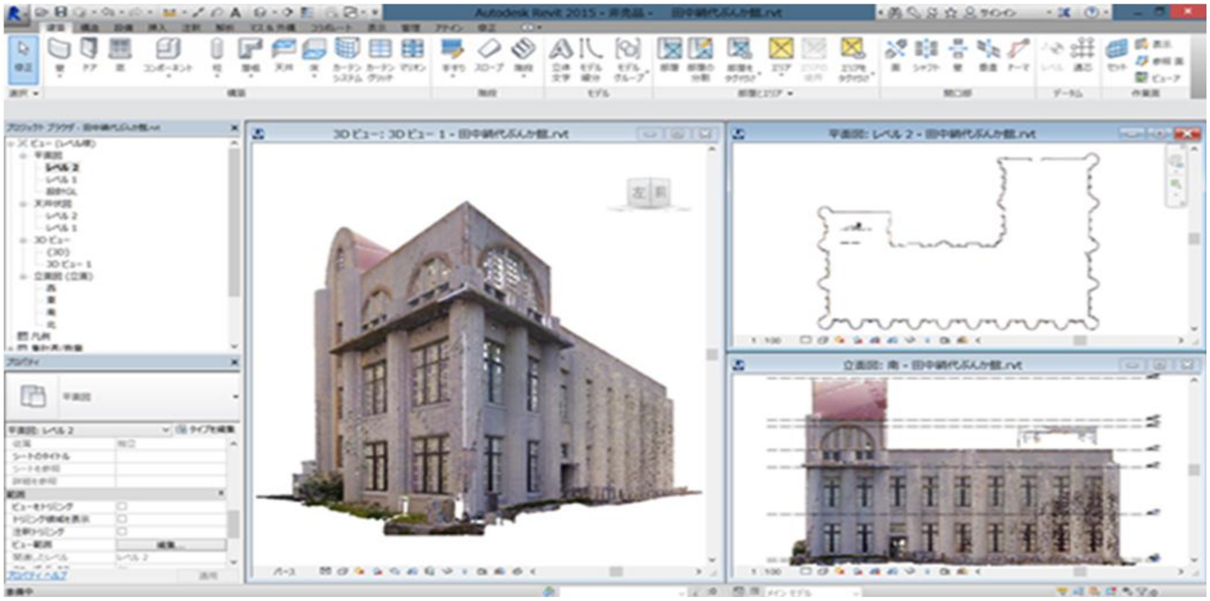


Fig.8. The first three-dimensional digital model in Japan for a registered historic building to help to preserve the museum. Source [7]

2. CONCLUSION

We recommend doing a building information model for all buildings to preserve and maintain them and provide digital copies to those who admire buildings around the world

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